AIR SERVICE INFORMATION CIRCULAR

(AVIATION)

PUBLISHED BY THE CHIEF OF AIR SERVICE, WASHINGTON, D. C.

Vol. IV October 15, 1922 No. 370

TEST OF A ZENITH CARBURETOR, MODEL U. S. 52 FITTED WITH "PLAIN TUBE" AND BRITTON TYPE DISCHARGE NOZZLES

(POWER PLANT SECTION REPORT)

Prepared by J. M. Miller, A. M. E.
Engineering Division, Air Service
McCook Field, Dayton, Ohio
May 10, 1922

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

CERTIFICATE: By direction of the Secretary of War the matter contained herein is published as administrative information and is required for the proper transaction of the public business.

TEST OF A ZENITH CARBURETOR MODEL U. S. 52 FITTED WITH "PLAIN TUBE" AND BRITTON TYPE DISCHARGE NOZZLES.

OBJECT OF TEST.

This test was conducted to determine the metering characteristics of the Zenith carburetor, Model U. S. 52, (1) as used in service on Liberty "6" and "12" aviation engines, (2) fitted as a "plain tube" carburetor (compensating fuel passage blank), and (3) with Britton type discharge nozzles.

CONCLUSIONS.

The "plain tube" setting retains the power and fuel consumption characteristics of the standard carburetor. The acceleration is good, but not equal to that of the standard setting, whereas the altimetric and load compensation are practically the same. It has no advantages as to operating characteristics over the standard setting. The acceleration of the Britton type discharge nozzle is definitely poor, making it impracticable for service use.

The Britton type discharge nozzle shows slightly less mixture enrichment up to 10,000 feet altitude, but a greater enrichment from 10,000 to 25,000 feet altitude than the standard setting. This nozzle has slight inherent load compensation if used in a strictly plain tube carburetor, that is, with a blank compensating jet in the Zenith U. S. 52. When used with the compensating jet which supplies fuel to the idle well only, this characteristic is not apparent, the load compensation being practically the same as that of the standard and the "plain tube" settings. The load compensation of the "plain tube" and Britton type discharge nozzle takes place through the idling passages.

DESCRIPTION.

The Britton type discharge nozzle was designed by Mr. K. B. Britton, of the Britton Carburetor Manufacturing Co. of Cleveland, Ohio, and consists of a cone-shaped nozzle with four outlet holes near the base of the cone, drilled at an angle of 45° with the center line. (See fig. 35.) This nozzle is screwed into the Zenith U. S. 52 carburetor body in place of the standard Zenith main jet and compensating discharge nozzle or cap jet. The threaded portion is long enough to blank off the compensating fuel passage, the compensating jet or metering orifice remaining in place to supply fuel to the idling well. The main metering orifice is screwed into the lower end of this discharge nozzle.

The "plain tube" arrangement was obtained by blanking the compensating fuel passage between the compensating metering jet and the discharge nozzle (see figs. 18 and 15). The compensating jet supplies fuel to the idling system only, as with the Britton type discharge nozzle.

METHOD OF TEST.

The runs made on this test may be divided into three general classes, (1) those conducted with the carburetor mounted on a Liberty "6" or "12" aviation engine on the dynamometer or torque stand to determine power, fuel consumption, and general operating characteristics, (2) those conducted in the carburetor test chamber to determine the metering characteristics of the carburetor with various settings, and (3) flight tests.

A Liberty "6" aviation engine was coupled to an electric cradle dynamometer and the following runs made with (1) the standard Zenith U. S. 52 setting, (2) Britton type discharge nozzles, and (3) the "plain tube" arrangement: several check runs at 1,700 revolutions per minute, full throttle, to determine the best setting, a full power run 1,200 revolutions per minute to 2,000 revolutions per minute, a propeller load run 1,700 revolutions per minute to 1,200 revolutions per minute, and runs to determine the acceleration. These runs were conducted and computations made as outlined in Engineering Division Report, Serial No. 1507. Domestic Aviation Gasoline, War Department Specification No. 2–40, was used during all the runs made on this test, including those in the carburetor test chamber. The time required for the engine to accelerate from 300 revolutions per minute to 1,200 revolutions per minute with rapid throttle opening and fixed electrical resistance was taken as a measure of acceleration in comparing the various carburetor setting and discharge nozzle combinations tried.

Runs were made with the Liberty "6" engine mounted on the torque stand to determine more accurately the propeller load and acceleration characteristics of the carburetor with the same nozzle arrangements as were used on the dynamometer runs. Five-minute fuel readings were made at full throttle, 1,500, 1,300, and 1,100 revolutions per minute, on a Liberty "12" engine on the torque stand with standard carburetors and with "plain tube" arrangement in the same carburetor.

The carburetor test chamber, used for determining the metering characteristics of this carburetor under various conditions of air flow and throttle opening, consists essentially of four parts, (1) a pump for producing the necessary air flow through the carburetor, (2) the box or test chamber proper in which the carburetor is mounted, (3) a Durley flat plate orifice for measuring the weight of air flow, and (4) a volumetric fuel measuring tank. The necessary manometers for measuring pressure differences at various points in the carburetor are also provided. Figures 16 and 17 show the box and manometer board.

The work in the carburetor test chamber was conducted in a manner to get a direct comparison of metering characteristics between the standard Zenith U. S. 52 carburetor and the same carburetor fitted with the "plain" and Britton type of discharge nozzles, and also to determine the effect of the component parts of the standard carburetor on mixture ratio. Runs simulating propeller load operation were made at ground level and 20,000 feet altitude and full throttle runs at each 5,000 feet altitude from

the ground level to 25,000 feet. The effect of float chamber vacuum was determined by taking several readings at various vacuums for each altitude increment up to 25,000 feet. In making runs in the carburetor test chamber two and often more readings were made for each condition of air flow, altitude, etc., and the results averaged.

Flight tests of the "plain tube" setting were made with a Liberty "6" engine mounted in airplane P–173 and with a Liberty "12" engine in airplane P–175. Flights were made to the service ceiling of each airplane and acceleration and general operation during maneuvers determined at various altitudes. Several cross-country flights were made with airplane P–175.

ANALYSIS OF RESULTS.

The operation of the Liberty "6" engine is practically the same with the "plain tube" arrangement as with the standard U. S. 52 setting. A slight difference in acceleration may be detected with a stop watch, the standard setting having the greater acceleration due probably to the fuel in the compensating fuel discharge nozzle and the idle well which is available as soon as the throttle is opened but is blanked off with the "plain tube" setting. The actual time in seconds for the engine to accelerate from 300 to 1,200 revolutions per minute with a fixed electrical resistance and rapid throttle opening was 5.4 for the "plain tube" and 4.8 for the standard setting. The acceleration of the engine with the Britton type discharge nozzle is definitely inferior to that obtained with the standard setting, the engine ceasing to fire if the throttle is opened quickly.

The fuel consumption curves for full throttle and propeller load operation are shown in Figures 1 and 2. The shape of the curves is practically the same for each setting tried indicating that load compensation is not seriously interfered with by blanking off the compensating fuel passage. The fact that compensation under these conditions takes place through the idle passages was clearly indicated by running the engine with blank compensating jets fitted in the standard or "plain tube" carburetor. Full throttle operation with the blank compensating jets was comparable to that of the standard or "plain tube" setting but on closing the throttle as on propeller load the mixture became so lean that the engine ceased firing.

Comparative curves of fuel flow and specific fuel consumption for the standard setting and the "plain tube" setting on a Liberty "12" mounted on the torque stand are shown in Figure 3. The fuel flow with the "plain tube" arrangement is approximately 8 per cent greater than that of the standard setting at cruising speeds, 1,400 to 1,600 revolutions per minute.

This difference in fuel flow does not check with the results obtained in the carburetor test chamber. (See curve sheet, fig. 11.) It is quite possible that part of the apparent increase in fuel flow, on the torque stand, of the "plain tube" setting over that of the standard was due to temperature and barometric differences. These atmospheric conditions indicate a greater density on the day when the "plain tube" carburetor was run, which would increase the amount of power required to drive the propeller at a given speed, thus increasing the amount of throttle opening required and hence the fuel flow.

The tabulated data on pages 22 and 23, most of which are shown in plotted form in Figures 4 to 14, indicate the character and results of the runs made in the carburetor test chamber.

The curves in Figure 4 indicate the altimetric compensation of the standard Zenith carburetor with the control in the full rich and full lean positions. The mixture enrichment [1] from ground level to 25,000 feet is 72.2 per cent with the control in the full rich position. The mixture range obtained by means of the mixture control is greatest at the ground, decreasing with increasing altitude. Ground level mixture may be maintained with the control to 15,000 feet altitude.

The altimetric compensation of the "plain tube" and Britton settings is shown by the curves in Figure 5. The enrichment of the "plain tube" setting from ground level to 25,000 feet in the full rich position is slightly less than that of the standard carburetor being 42.5 per cent as compared to 72.2 per cent. The enrichment of the Britton type discharge nozzle over the same altitude range is practically the same as that of the standard setting but has a slightly different form of mixture ratio curve, showing less enrichment up to 10,000 feet altitude and a greater enrichment between 10,000 feet and 25,000 feet altitude. The range of the mixture control is somewhat less for the plain tube than the standard setting giving ground level mixture to an altitude of approximately 12,500 feet.

Load compensation curves of the standard carburetor and setting are shown in Figure 6. The mixture enrichment on propeller load from 1,700 to 1,300 revolutions per minute is slight, 11.5 per cent at ground level, full rich, and approximately the same at 20,000 feet altitude, full rich and full lean. The greater enrichment of the mixture in the full lean position at ground level is through a range of mixture ratios much too lean for engine operation.

Mixture ratio characteristics of the "plain tube" setting on propeller load are shown in Figure 7. The change in mixture ratio is practically the same as that of the standard setting, the absolute values being slightly leaner. This latter condition is to be expected as the fuel flow through the compensating fuel passage was cut off. The curve obtained with the compensating jet blank indicates clearly that the compensation obtained with the "plain tube" setting takes place through the idling passages. This curve is characteristic for a plain jet in a single venturi, the mixture becoming lean as the throttle is closed.

The curve sheet, Figure 8, shows the load compensation of the Britton type discharge nozzle at ground level and 20,000 feet altitude. With the standard size compensating jet in place, so that compensation may take place through the idle passages, this nozzle gives practically the same mixture ratio change over propeller load as does the standard discharge nozzle with or without the compensating fuel passage blanked. With a blank compensating jet, however, the Britton type discharge nozzle shows slight inherent load compensation characteristics, the mixture becoming leaner as the throttle is closed but not to the same extent as with the standard discharge nozzle under the same conditions.

[1] Per cent mixture enrichment $= \dfrac{\left(\frac{1}{y} - \frac{1}{x}\right)}{\frac{1}{x}} \times 100$ where x = mixture ratio, lb. air/lb. fuel, ground level. y = mixture ratio lb. air/lb. fuel, 25,000 ft. altitude.

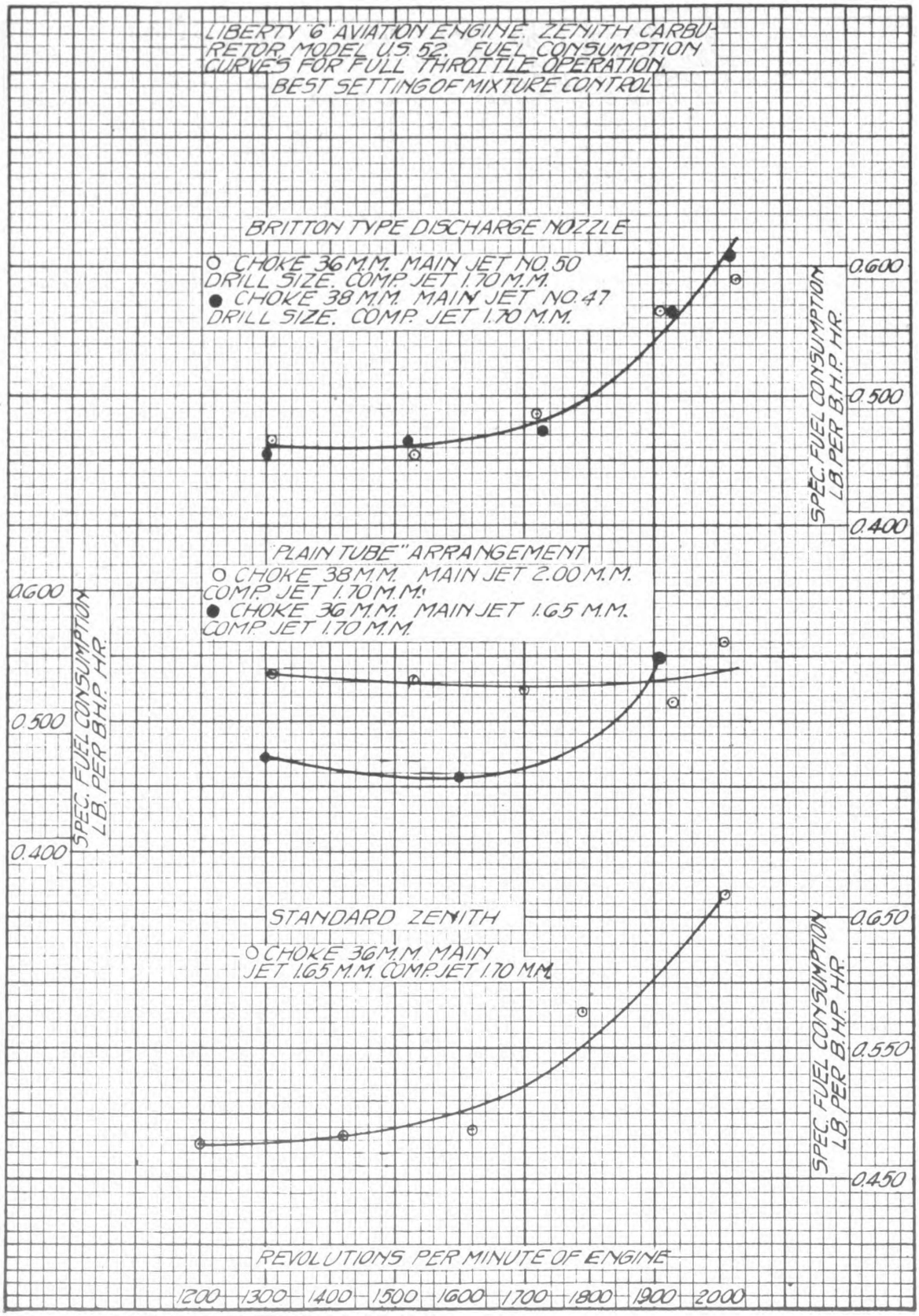

FIG. 1.

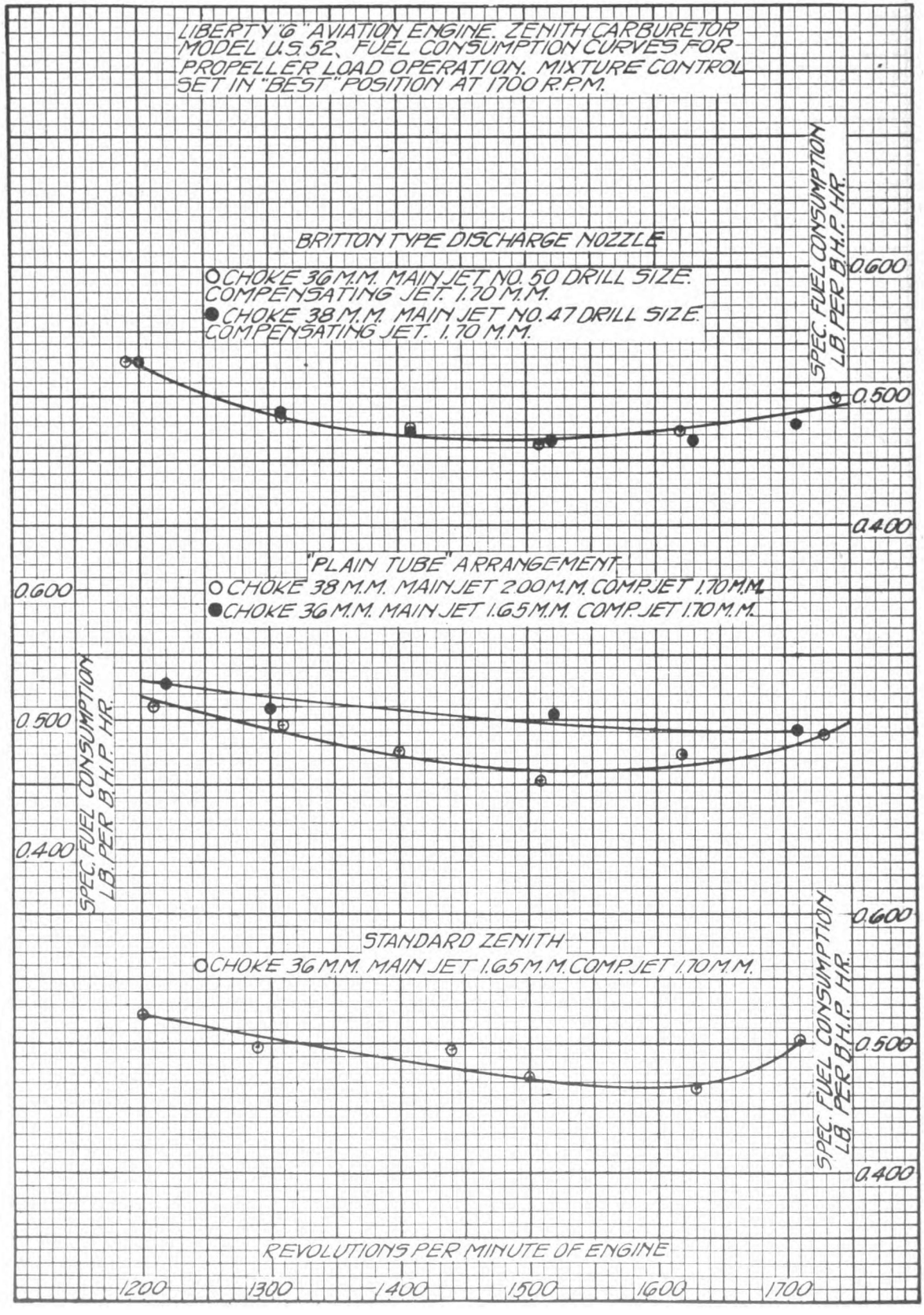

FIG. 2.

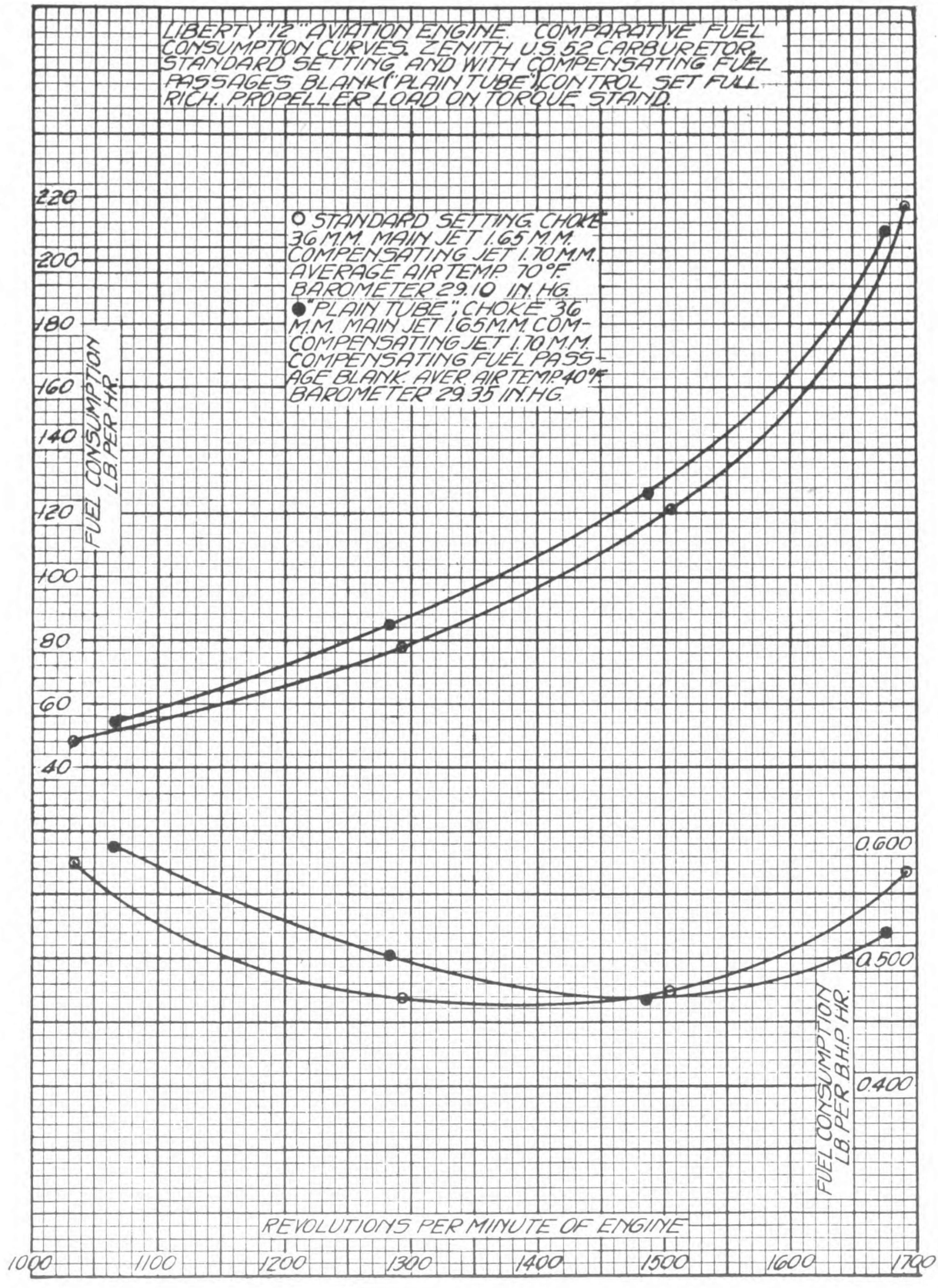

FIG. 3.

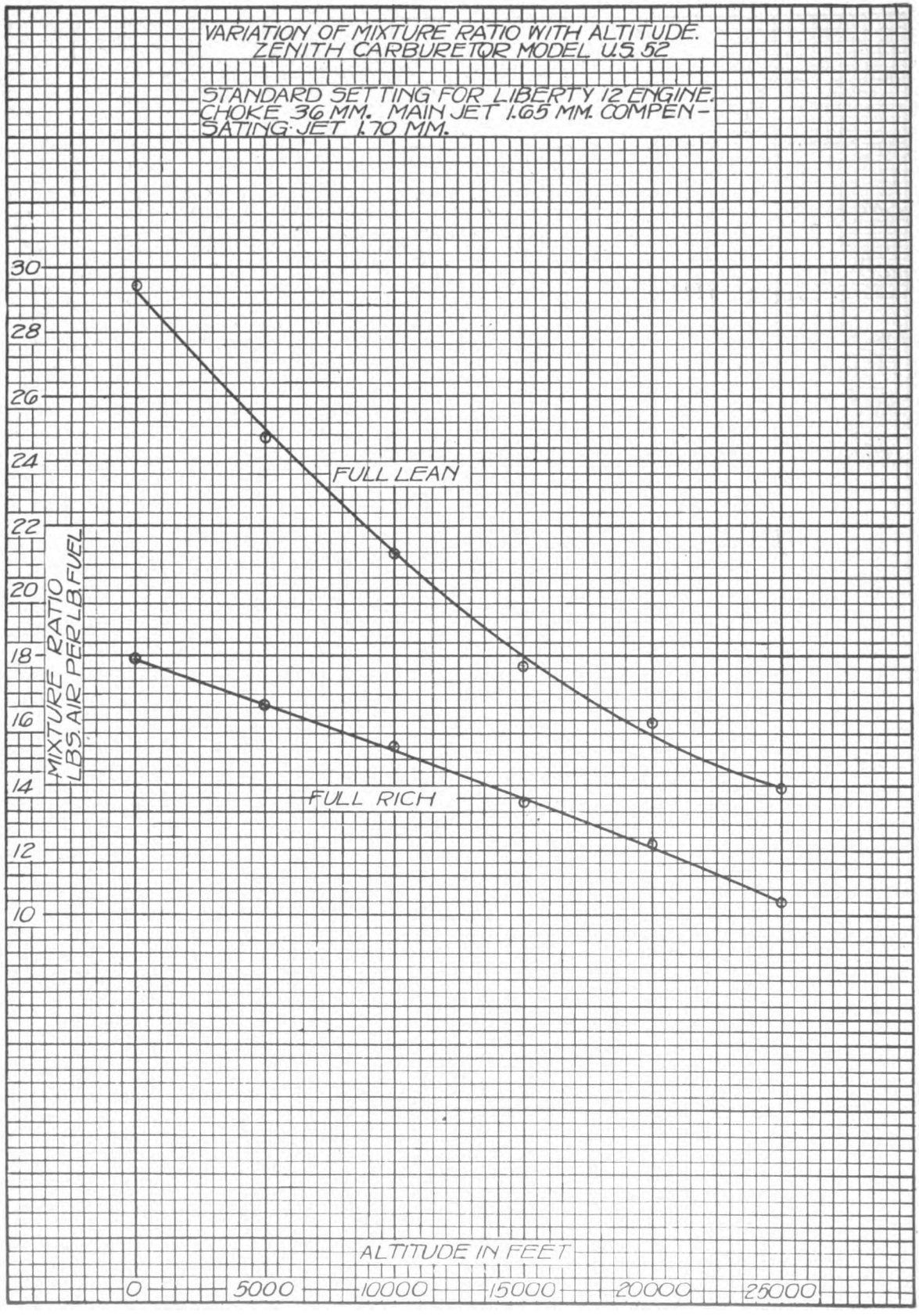

FIG. 4.

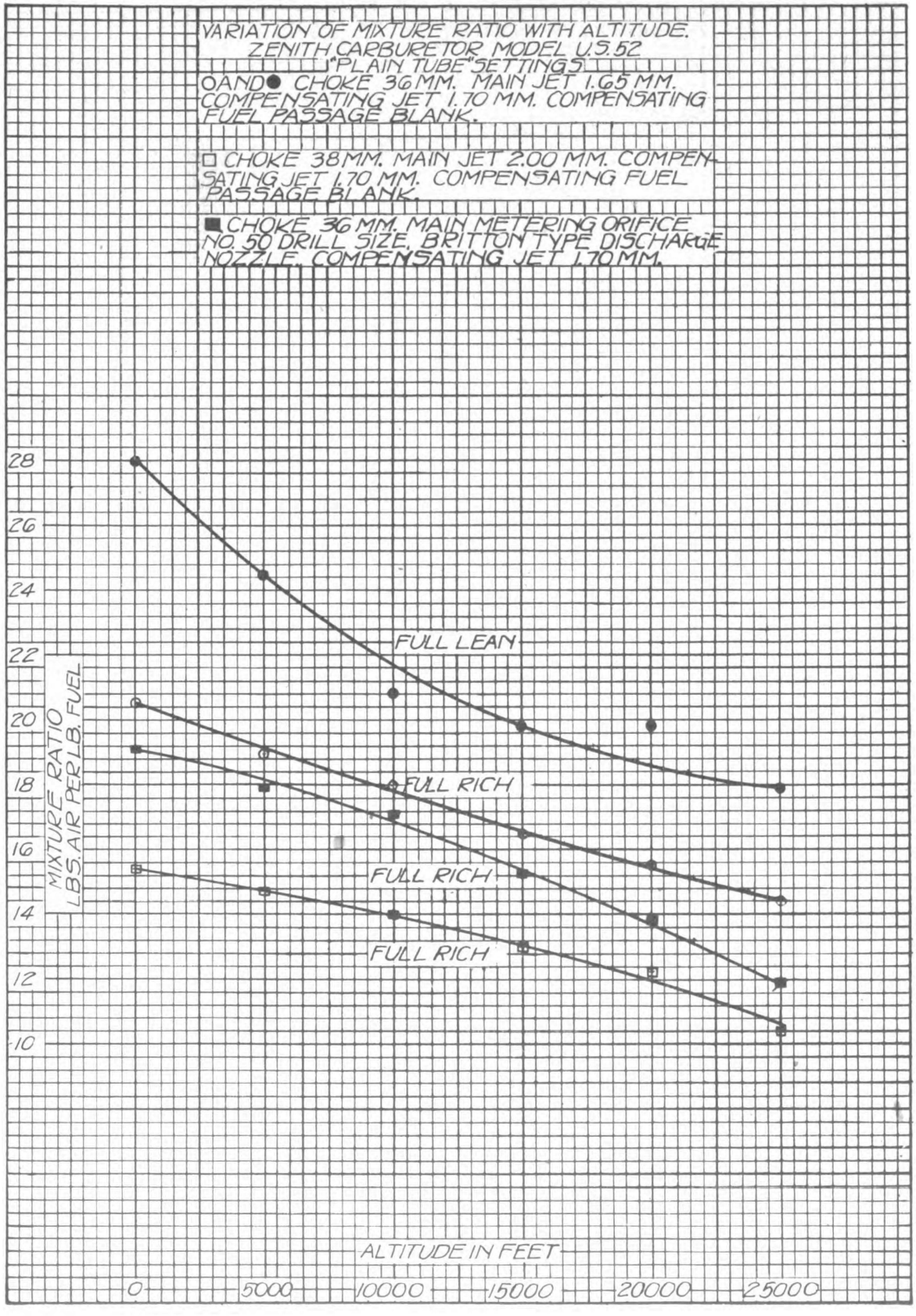

Fig. 5.

4769--22---2

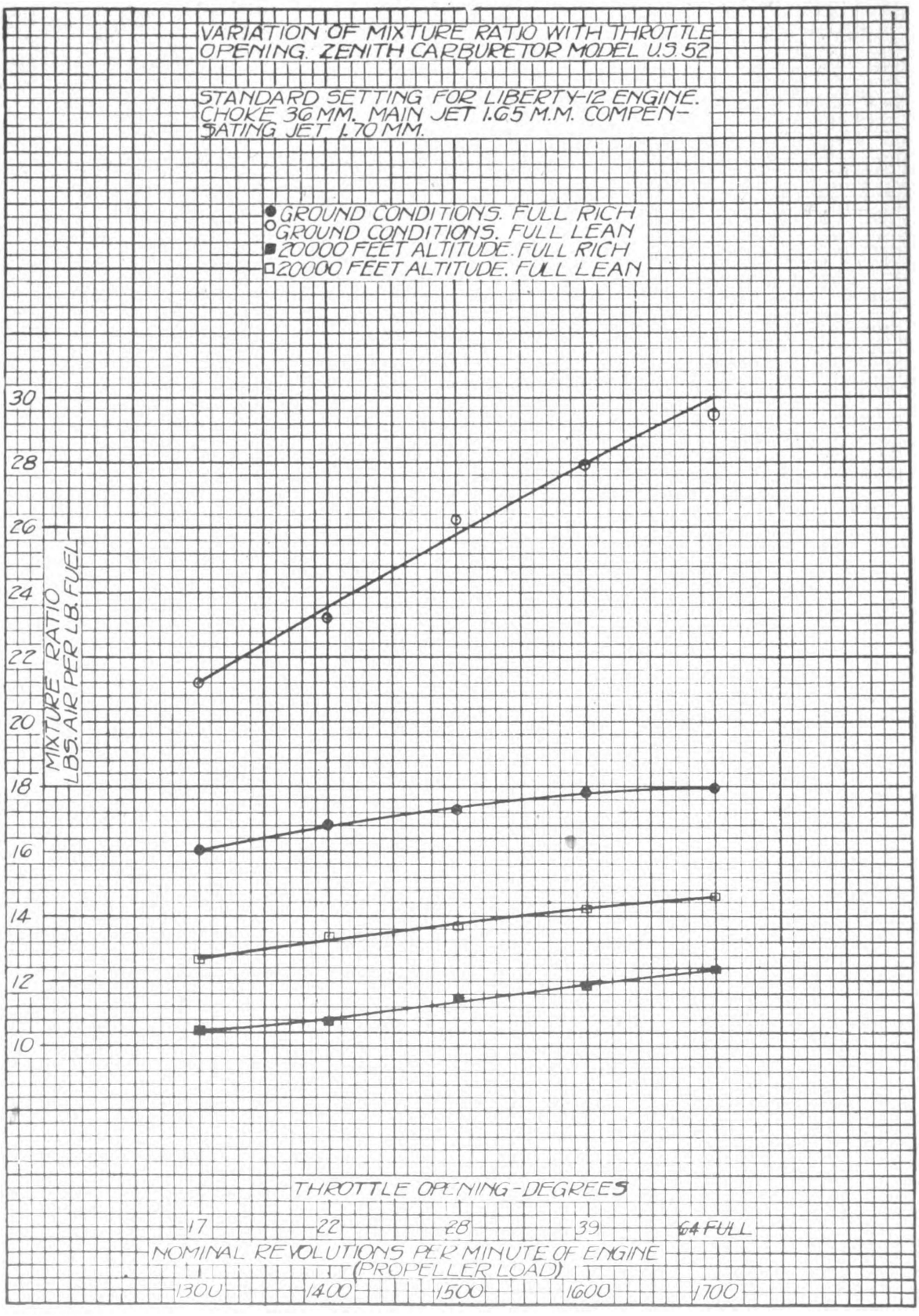

FIG. 6.

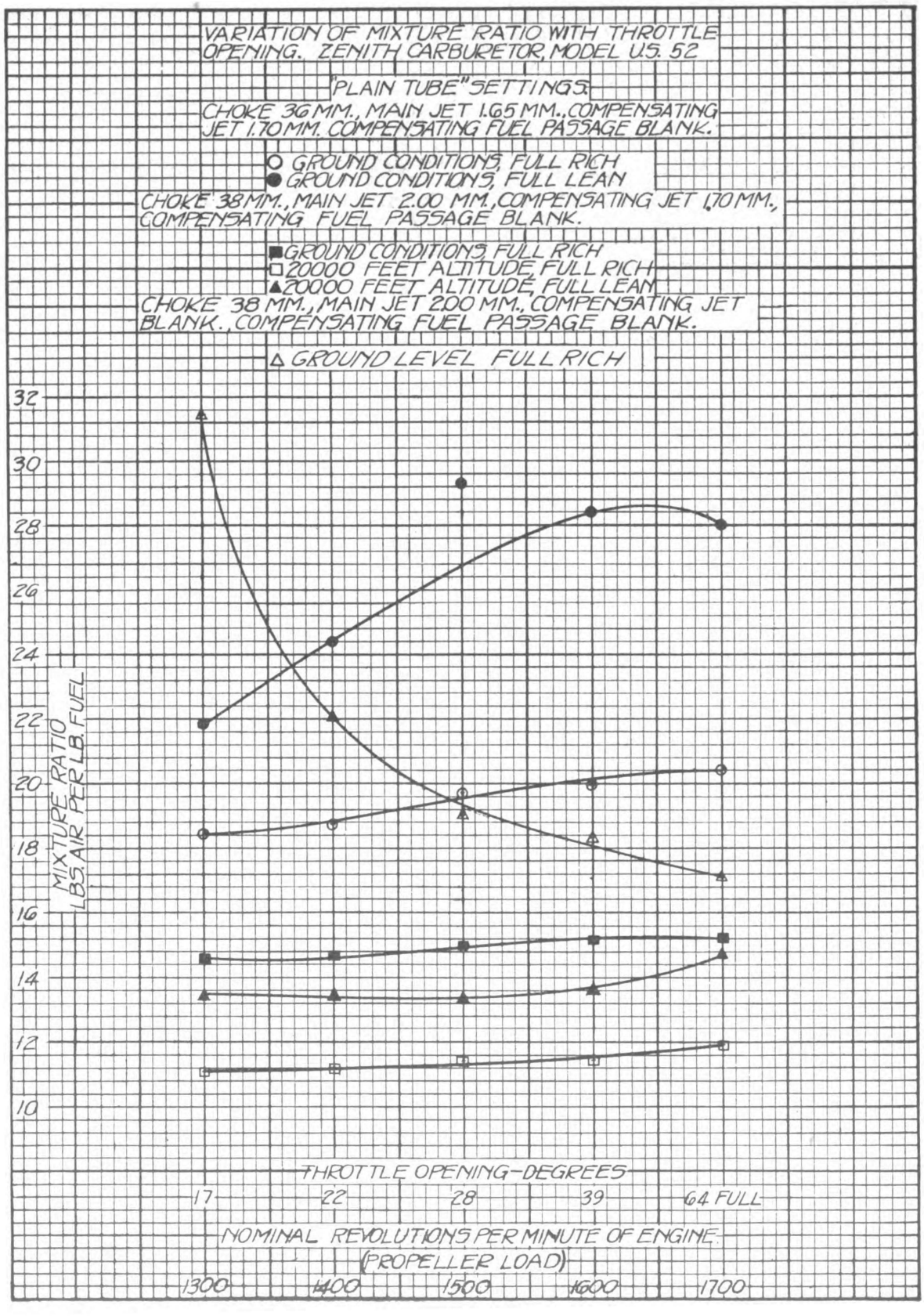

FIG. 7.

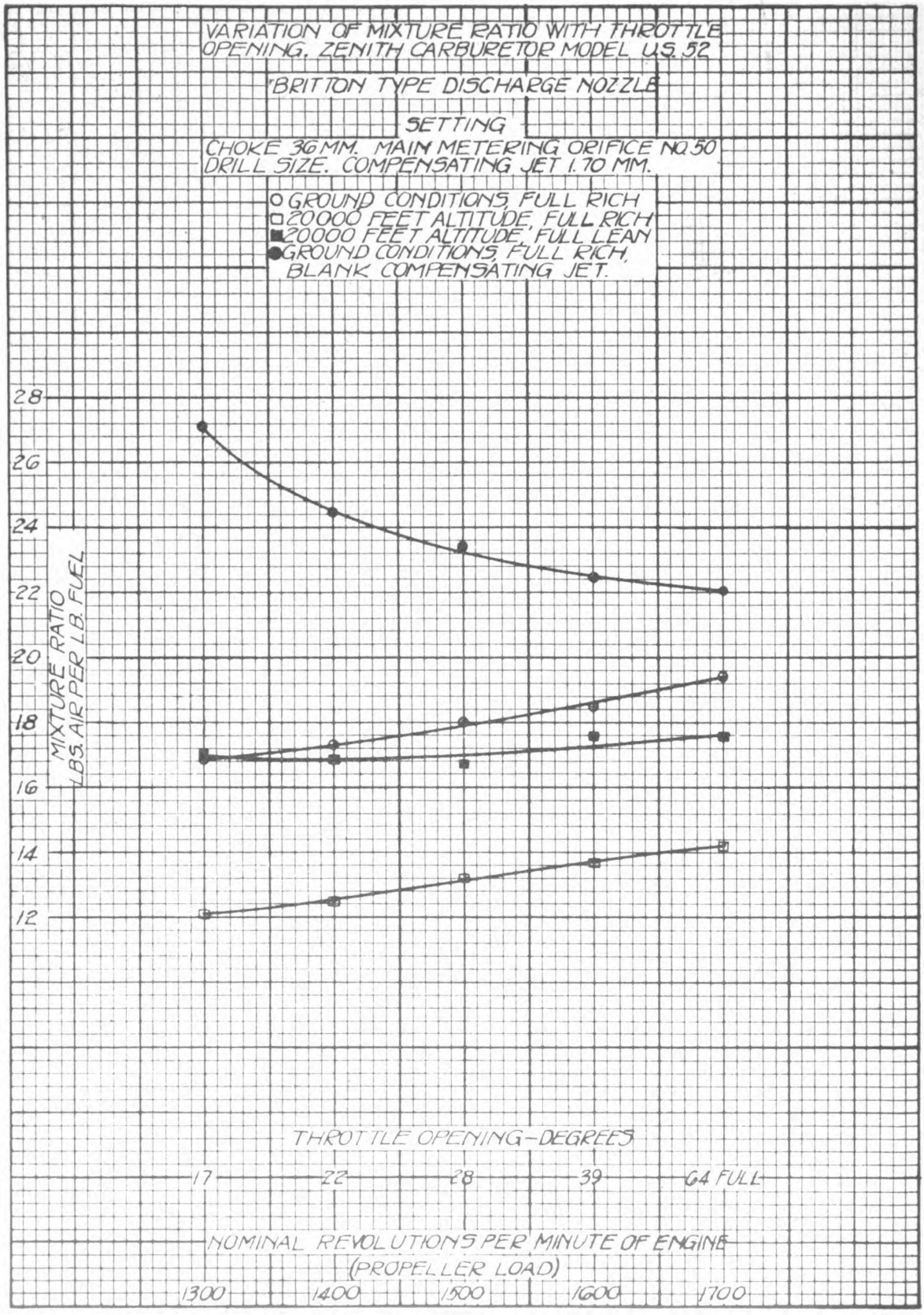

FIG. 8.

The mixture ratios obtained with each jet separately and with the standard carburetor are shown in Figure 9. The data on the standard carburetor setting plotted on this curve sheet as a basis for comparison are the same as that plotted in Figure 6 but to a different scale. The curve obtained with the compensating jet only, full lean, is discontinued at 1,430 revolutions per minute and a mixture ratio of 90, the slope indicating that at full throttle practically no fuel flows through the compensating jet. This curve is continued to 1,600 revolutions per minute in Figure 10. The effect of the control on the main jet is approximately the same at all speeds on propeller load, the mixture ratio curves being very nearly parallel. The difference in mixture ratio curves, full rich and full lean, of the standard carburetor is, therefore, due to the change of fuel flow through the compensating jet.

The curve showing mixture ratio on propeller load of the idling discharge jet only (see fig. 10) was obtained with the main jet blank and the compensating fuel passage blank. The curve of fuel flow under the same conditions is shown in Figure 11. This does not indicate, however, the quantity which passes through the idling passages of the standard carburetor at full throttle, but checks very closely with the values of fuel flow as obtained by subtracting the flow through the main jet alone from that of the "plain tube" setting. The fuel flow curves in Figure 11 are plotted from the same data as the mixture ratio curves in Figures 9 and 10.

The fuel flow, with the control in the full lean position, is shown for various jet combinations in Figure 12. The use of the control brings the fuel-flow curves of the standard and the "plain tube" settings together over the full propeller load range, and reduces the flow through the compensating jet to practically zero at 1,700 revolutions per minute.

The effect of float-chamber vacuum on mixture ratio at various altitudes is shown by the curves in Figure 13. These curves indicate the characteristics of the back-suction type of control as applied to a carburetor using a gravity flow compensator jet.

The curve in Figure 14, variation of mixture ratio with air flow, shows the ratios corresponding to full throttle operation.

The flight tests made with the "plain tube" setting on a Liberty "6" engine in airplane P-173 and on a Liberty "12" engine in airplane P-175 indicate the "plain tube" setting to be equal in performance to the standard setting both as to load and altimetric compensation characteristics.

Liberty "6" engine—Standard Zenith carburetor, model U. S. 52.

FULL POWER RUN.

R. P. M.	Actual.		Corrected.			Water.		Oil.			Carb. air temp. °F.	Man. vac. in. hg.	Fuel cons.		Float chamber vac. in. H_2O.	Position[1] of alt. control.
	Brake load lb.	B.H.P.	Torque lb. ft.	H.P.	B.M.E.P. lb. per sq. in.	Temp. °F. In.	Temp. °F. Out.	Temp. °F. In.	Temp. °F. Out.	Press. lb. per sq. in.			Sec. for 3-lbs.	Lb. per hp. hr.		
1,200	383	153.2	682	156.0	124.7	148	162	74	102	25	54	1.1	148	0.477	.....	5.5
1,310	376	165.0	674	168.0	123.4	150	170	80	110	26	58	1.3	.....	.....	4.6	5.45
1,420	380	180.0	678	183.2	124.0	150	170	90	118	26	54	1.5	124	.484	4.2	6.25
1,510	378	190.2	674	193.6	123.4	152	172	92	110	26	56	1.6	.....	.....	4.5	6.60
1,620	368	198.7	656	202.2	120.0	152	172	94	108	26	58	1.8	111	.489	5.4	6.45
1,730	352	203.0	628	206.6	114.9	152	170	100	108	26	58	1.9	.....	.....	5.8	6.85
1,790	319	190.2	568	193.6	104.0	152	170	106	116	26	.....	2.0	98	.579	6.6	7.25
1,890	294	185.2	524	188.5	95.8	148	168	106	122	27	56	2.2	.....	.....	7.2	7.25
2,010	249	166.8	444	169.8	81.2	154	174	106	130	27	56	2.2	97	.668	7.8	7.25

PROPELLER LOAD RUN.

R. P. M.	Actual.		Corrected.		Water.		Oil.			Carb. air temp. °F.	Man. vac. in. hg.	Fuel cons.		Carb. float cham. in. H_2O.	Position[1] of alt. control.
	Brake load lb.	B.H.P.	Torque lb. ft.	H.P.	Temp. °F. In.	Temp. °F. Out.	Temp. °F. In.	Temp. °F. Out.	Press. lb. per sq. in.			Sec. for 3 lbs.	Lb. per hp. hr.		
1,710	356	203.0	634	206.8	152	170	111	110	28	56	1.4	106	0.502	6.0	6.50
1,630	309	168.0	551	171.0	152	168	110	108	28	56	3.2	138	.466	4.2	6.50
1,500	272	136.0	484	138.5	154	168	106	100	27	58	3.9	[2] 112	.473	3.2	6.50
1,440	240	115.2	430	117.3	156	170	102	104	26	58	4.6	[2] 126	.496	2.8	6.50
1,290	204	87.7	363	89.3	156	168	102	116	26	.....	7.7	[2] 165	.498	2.2	6.50
1,200	174	69.6	310	70.9	154	170	102	120	25	58	9.7	[2] 198	.522	2.0	6.50

Data for both runs:
Length of brake arm, 21 inches.
Average barometer, 29.40 in. hg.
Kind of oil used, U. S. Spec. No. 3501—Viscosity of oil, 115-125 at 210 °F.

Kind of fuel used, aviation gasoline, W. D. Spec. No. 2-40.
Specific gravity of fuel, 0.707 at 60° F.
Carburetor setting: Choke, 36 mm.; main jet, 1.65 mm.; comp. jet, 1.70 mm.

[1] Mixture control setting: F. R., 7.75; F. L., 0.

[2] Two pounds fuel.

Date of run: February 12, 1921.

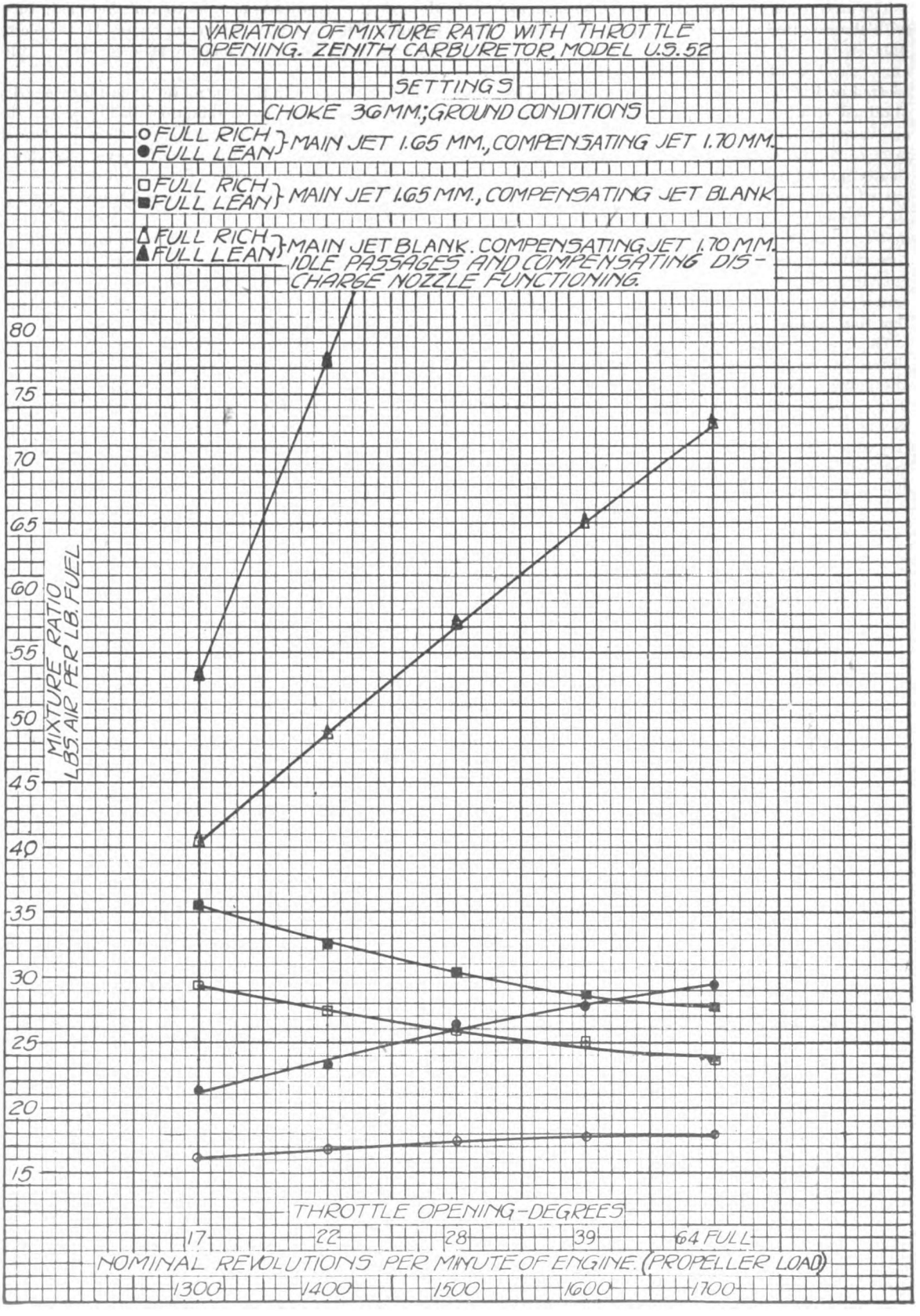

FIG. 9.

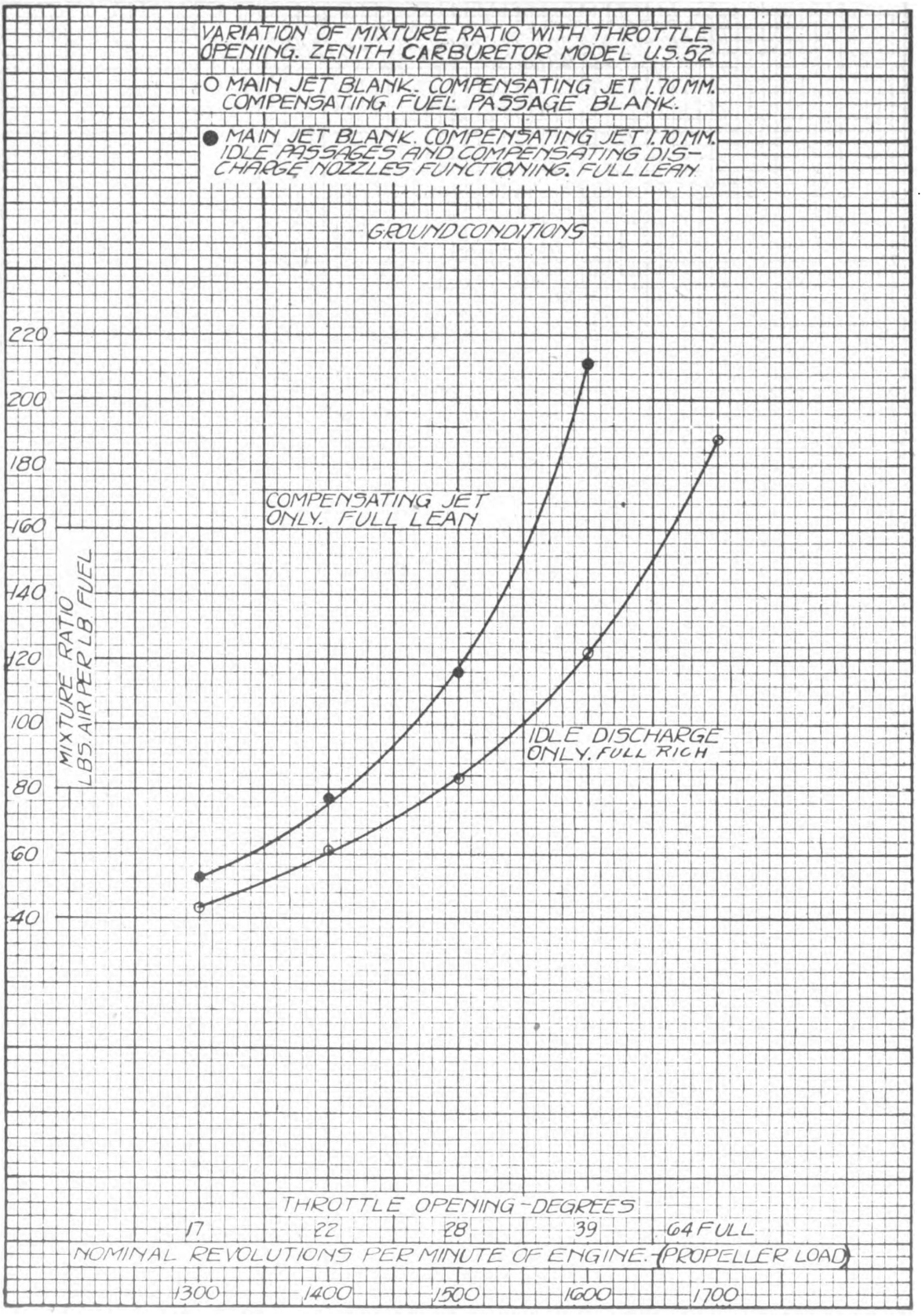

FIG. 10.

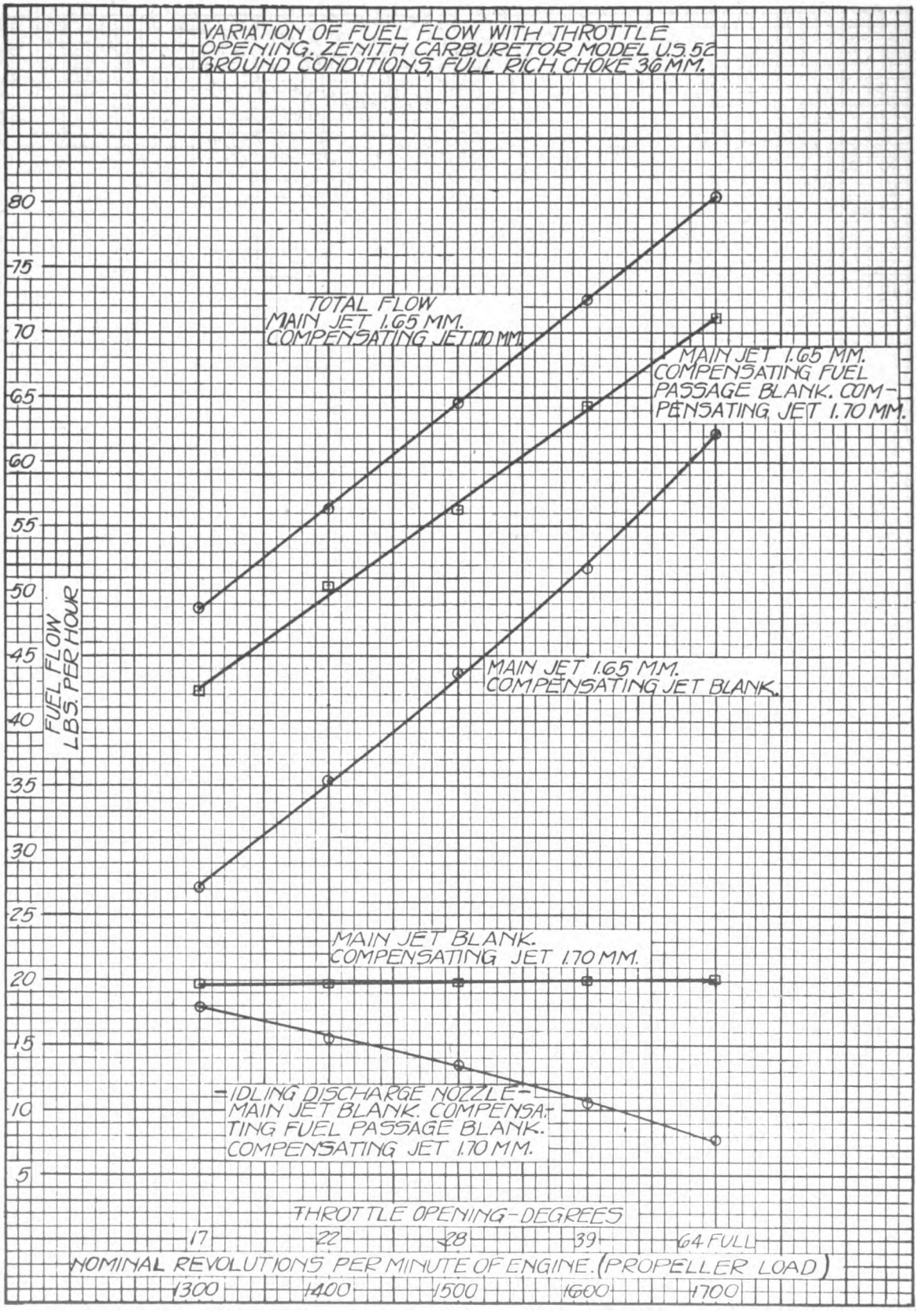

FIG. 11.

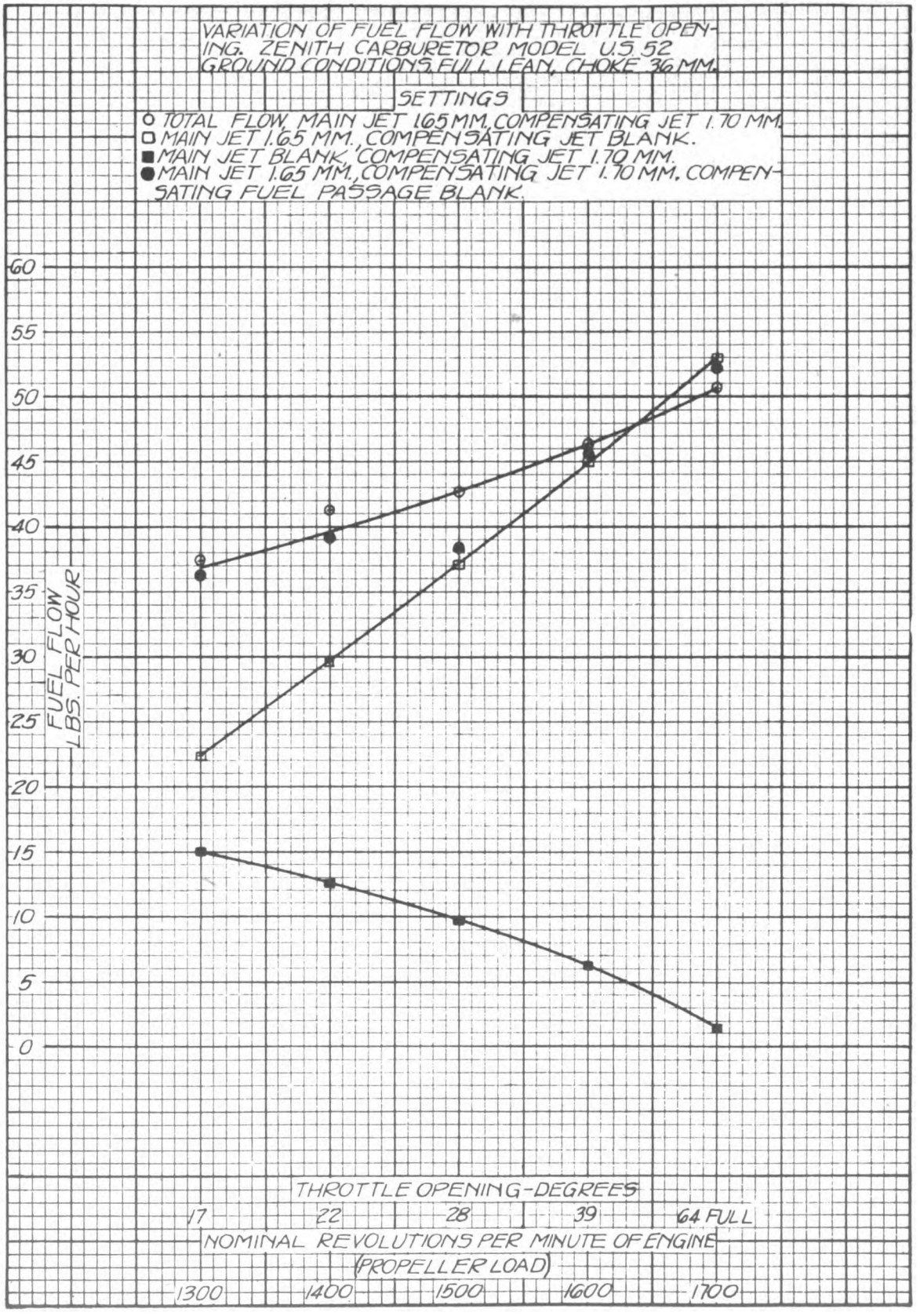

FIG. 12.

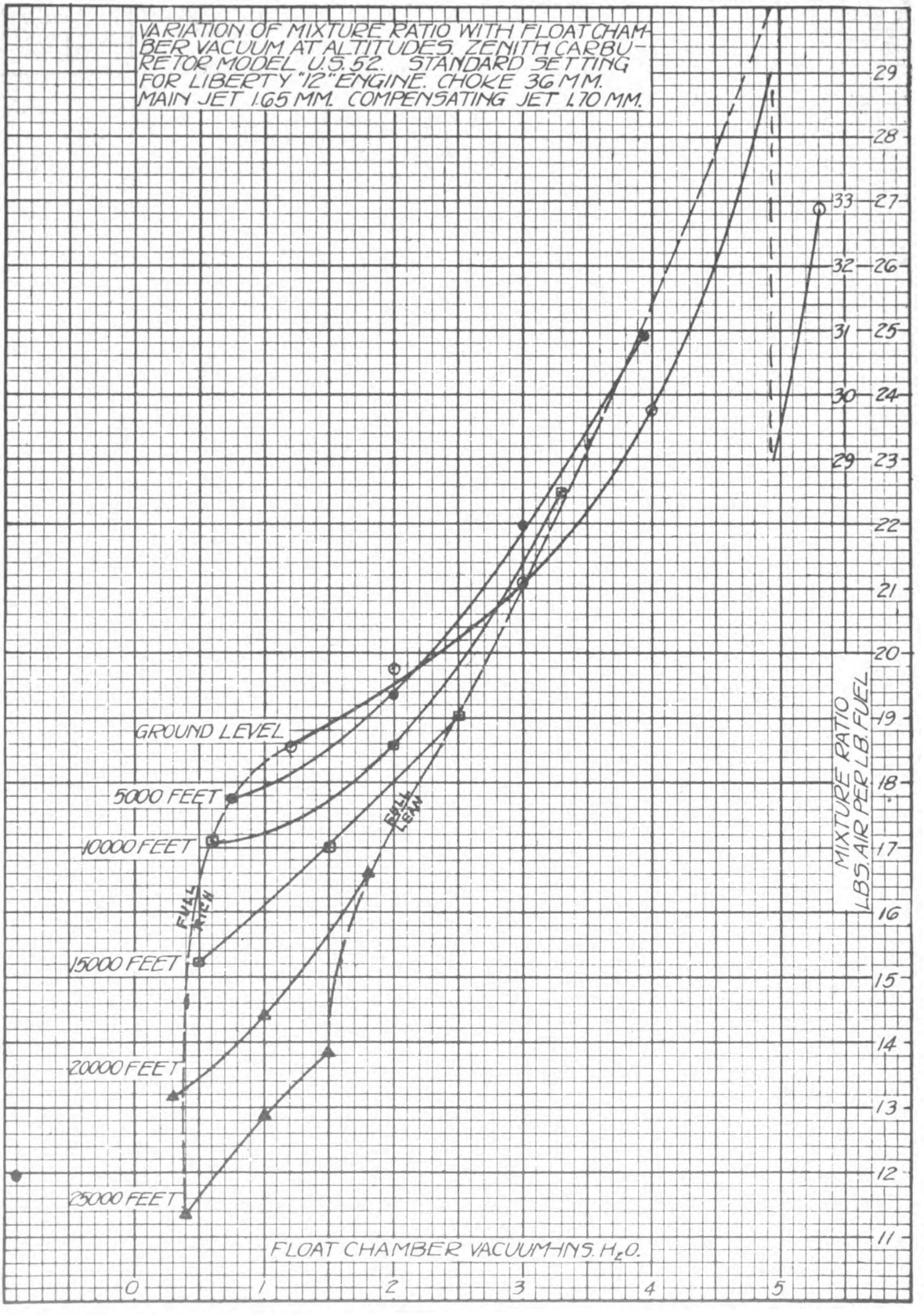

FIG. 13.

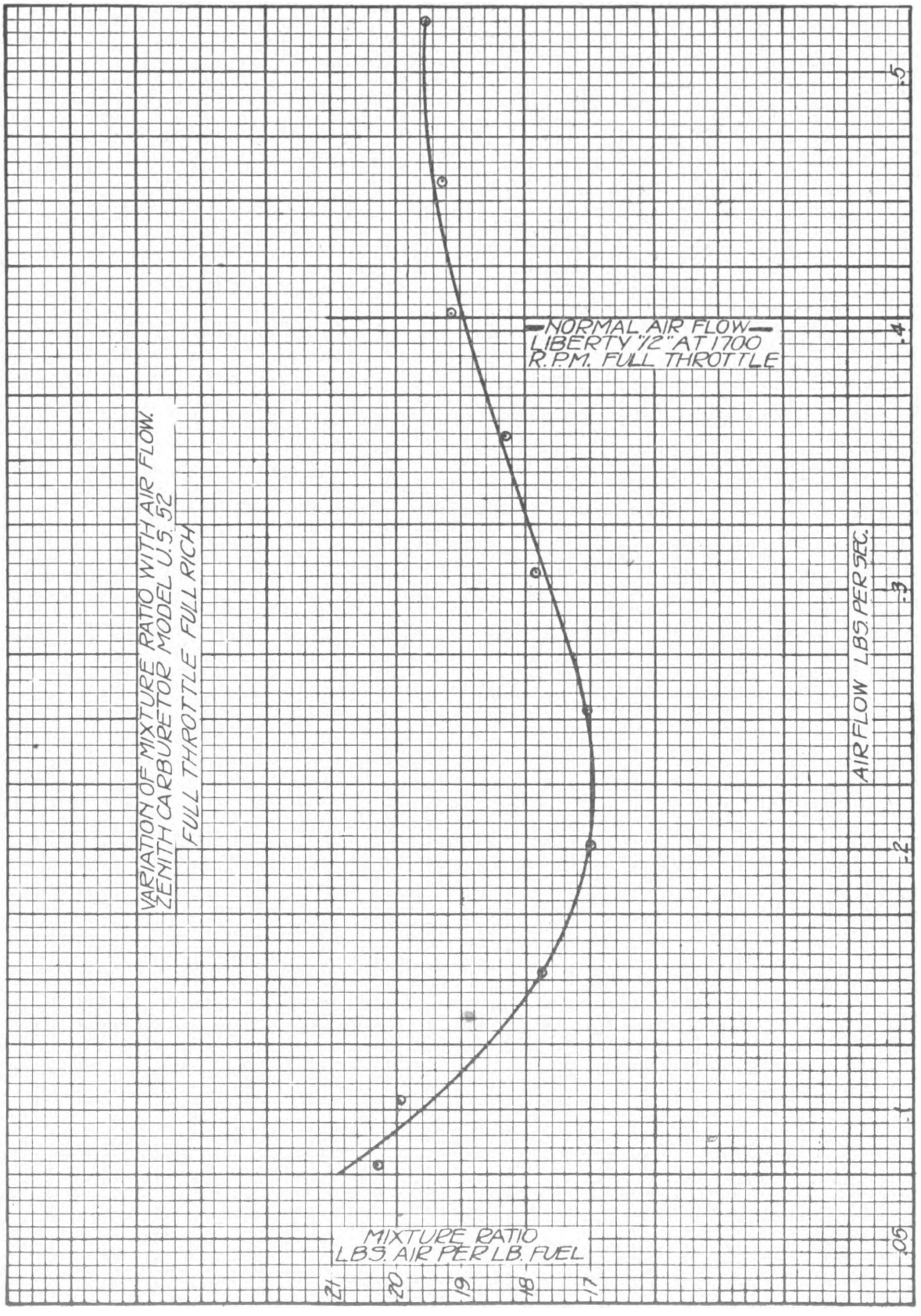

FIG. 14

Liberty "12" aviation engine—Five minute fuel consumption runs on torque stand—Zenith U. S. 52 carburetor.

STANDARD SETTING.

R. P. M.	Actual.		Corrected H. P.	Man. vac. in. hg.	Float chamber vac. in. H_2O.		Mixture control position.	Fuel cons.	
	Brake load lb.	B. H. P.			Prop. end.	Gear end.		Lb./hr.	Lb./hp/hr.
1,692	294	382.5	393.2	1.7	10.3	9.1	F. R.	217.2	0.568
1,696	297	387.8	398.5	1.8	11.9	9.9	Best	204.0	.526
1,506	220	255.0	262.0	4.5	6.4	5.7	F. R.	121.2	.475
1,488	215	246.0	253.0	4.4	6.5	5.8	Best	118.8	.483
1,294	167	166.2	171.0	9.6	2.6	2.4	F. R.	78.0	.469
1,272	159	155.5	160.0	9.3	3.5	2.6	Best	78.0	.501
1,034	105	83.5	85.8	14.4	1.4	1.1	F. R.	48.0	.575
966	98	72.8	74.8	14.0	1.0	1.2	F. L.	45.6	.626

NOTE.—Engine operation rough at 1,000 R. P. M. settings.

Length of brake arms, 48.5 in.
Fuel used (Spec. grav.), 0.710 at 60° F., W. D. Spec. 2–40.
Barometer, 29.10 in. hg.
Oil used, U. S. Spec. No. 3501, viscosity, 115-125 at 210 ° F.
March 24, 1922.

Average air temp., 70° F.
Outlet water temp., 170° F.
Carburetor settings: Carburetor used, Zenith U. S. 52; Chokes, 36 mm.; Main jets, 1.65 mm.; Comp. jets, 1.70 mm.

Liberty "6" engine—Zenith carburetor, model U. S. 52, "plain tube" arrangement, compensating fuel passage blank.

FULL-POWER RUNS.

R. P. M.	Actual.		Corrected.			Water.		Oil.			Carb. air temp. °F.	Man. vac. in. hg.	Fuel cons.		Float chamber vac. in. H_2O.	Position [1] of alt. control.
	Brake load lb.	B.H.P.	Torque lb. ft.	H. P.	B. M. E. P. lb. per sq. in.	Temp. °F. In.	Temp. °F. Out.	Temp. °F. In.	Temp. °F. Out.	Press. lb. per sq. in.			Sec. for 3 lbs.	Lb. per hp.-hr.		
1,310	368	160.7	664	165.7	121.5	152	172	92	100	25	72	1.2	125	0.537	5.4	0.75
1,530	369	188.2	666	194.0	121.9	154	172	98	100	26	72	1.5	108	.532	5.8	4.50
1,700	344	195.0	620	201.0	113.4	156	174	100	108	26	73	1.7	106	.525	7.0	5.00
1,930	270	173.8	467	179.2	89.1	152	168	102	122	27	72	1.9	121	.514	8.3	5.25
2,010	254	170.2	459	175.5	84.0	152	172	108	120	28	72	2.0	113	.561	8.3	5.50

Carburetor setting: Chokes, 38 mm.; main jet, 2.00 mm.; comp. jet, 1.70 mm. Barometer: 29.02 in. hg. February 15, 1921.

1,300	380	164.6	682	168.5	124.7	152	172	122	134	27	60	1.2	139	0.472	3.6	5.75
1,600	368	196.2	658	200.8	120.4	152	171	124	144	28	60	1.6	120	.459	5.2	6.00
1,910	300	191.0	538	195.4	98.4	154	172	122	130	28	60	1.8	103	.549	7.4	6.25

Carburetor setting: Chokes, 36 mm.; main jet, 1.65 mm.; comp. jet, 1.70 mm. Barometer: 29.28 in. hg.
Data for both runs: Length of brake arm, 21 in.; kind of oil used, U. S. Spec. No. 3501; viscosity 115–125 at 210° F.; kind of fuel used, aviation gasoline, W. D. Spec. 2–40; specific gravity, 0.707 at 60° F. March 3, 1921.
[1] Mixture control setting: F. R., 7.5; F. L., 0.75.

PROPELLER-LOAD RUNS.

R. P. M.	Actual.		Corrected.		Water.		Oil.			Carb. air temp. °F.	Man. vac. in. hg.	Fuel cons.		Float chamber vac. in. H_2O.	Position [1] of alt. control.
	Brake load lb.	B.H.P.	Torque lb. ft.	H. P.	Temp. °F. In.	Temp. °F. Out.	Temp. °F. In.	Temp. °F. Out.	Press. lb. per sq. in.			Sec. for 3 lbs.	Lb. per hp.-hr.		
1,730	342	197.4	618	203.4	152	168	108	116	28	.....	1.8	112	0.489	7.0	5.0
1,620	302	163.0	544	168.0	154	169	110	112	27	72	3.7	140	.473	4.2	5.0
1,510	266	133.9	480	138.0	154	168	114	112	27	73	5.5	[2] 119	.452	3.0	5.0
1,400	230	107.4	415	110.7	156	170	112	110	26	72	7.6	[2] 141	.476	2.5	5.0
1,310	199	86.9	358	89.6	156	170	110	106	26	72	9.6	[2] 167	.496	2.0	5.0
1,210	168	67.8	200	69.9	158	172	106	101	25	72	10.7	[2] 208	.510	1.6	5.0

Carburetor setting: Chokes, 38 mm.; main jet, 2.00 mm.; comp. jet, 1.70 mm. Barometer: 29.02 in. hg. February 15, 1921.

1,710	351	200.0	628	204.6	152	170	122	126	28	58	1.7	[3,4] 110	0.491	6.2	6.00
1,520	273	138.4	489	141.5	152	168	122	120	28	60	3.8	[3,4] 103	.504	2.8	6.00
1,300	204	88.4	365	90.4	158	174	118	112	26	60	6.3	[4] 80	.509	2.2	6.00
1,220	178	72.4	319	74.0	156	168	116	108	26	60	8.4	[4] 94	.529	1.8	6.00

Carburetor setting: Chokes, 36 mm.; main jet, 1.65 mm.; comp. jet, 1.70 mm. Barometer: 29.28 in. hg. March 3, 1921.
Data for all runs: Length of brake arm, 21 in.; kind of oil used, U. S. Spec. No. 3501; viscosity, 115–125 at 210° F.; kind of fuel used, aviation gasoline, W. D. Spec. No. 2–40; specific gravity of fuel, 0.707 at 60° F.
[1] Mixture control setting: F. R., 7.50; F. L., 0.75.
[2] 2 pounds fuel.
[3] 3 pounds fuel.
[4] Sec. 1 lb.

Liberty "12" aviation engine—five-minute fuel-consumption runs on torque stand—Zenith U. S. 52 carburetor.

"PLAIN TUBE" SETTING.

R. P. M.	Actual. Brake load, lb.	Actual. B. H. P.	Corrected H. P.	Man. vac. in. hg.	Float chamber vac. in. H_2O. Prop. end.	Float chamber vac. in. H_2O. Gear end.	Mixture control position.	Fuel cons. Lb./hr.	Fuel cons. Lb./hp./hr.
1,676	312.0	402.0	410.0	1.7	9.1	7.8	F. R	209.0	0.520
1,670	307.0	394.0	402.0	1.7	10.7	8.4	Best	198.0	.503
1,488	235.0	269.0	274.0	4.4	4.9	4.3	F. R	126.0	.468
1,494	231.5	266.0	271.0	4.3	5.1	4.4	Best	129.6	.487
1,284	172.0	170.0	173.4	10.0	2.3	1.5	F. R	85.2	.501
1,278	170.0	167.0	170.3	10.0	2.3	2.1	Best	84.0	.503
1,066	112.0	91.8	93.6	14.0	1.1	1.1	F. R	54.0	.588
1,030	107.5	85.2	86.9	15.1	1.1	1.1	Best	48.0	.563

Length of brake arm, 48.5 in.; fuel used (spec. grav.), 0.710 at 60° F., W. D. Spec. 2–40; barometer, 29.35 in. hg.; oil used, U. S. Spec. No. 3501, viscosity 115–125 at 210° F., average air temp., 40° F.; outlet water temp., 170° F.
Carburetor settings: Carburetor used, Zenith U. S. 52; chokes, 36; main jets, 1.65 mm., comp. jets, 1.70 mm. compensating fuel passage blank. March 22, 1922.

Liberty "6" engine—Zenith carburetor, Model U. S. 52, Britton type discharge nozzles.

FULL POWER RUNS.

R P.M.	Actual. Brake load, lb.	Actual. B.H.P.	Corrected. Torque, lb. ft.	Corrected. H. P.	Corrected. B. M. E. P. lb. per sq. in.	Water. Temp. ° F. In.	Water. Temp. ° F. Out.	Oil. Temp. ° F. In.	Oil. Temp. ° F. Out.	Oil. Press. lb. per sq. in.	Carb. air temp. ° F.	Man. vac. in. hg.	Fuel cons. Sec. for 3 lb.	Fuel cons. Lb. per hp. hr.	Float chamber vac. in H_2O.	Position[1] of alt. control.
1,310	369	161.0	662	165.0	121.1	152	171	93	112	25	56	1.5	144	0.466	2.8	6.75
1,530	354	180.5	636	185.0	116.4	154	170	96	106	26	56	2.0	132	.453	3.5	6.75
1,720	329	188.5	590	193.2	108.0	153	172	102	112	26	60	2.4	118	.486	4.4	6.80
1,910	270	172.0	485	176.4	88.8	160	178	102	118	26	60	2.8	111	.566	5.0	7.75
2,030	246	166.5	441	170.6	80.7	148	165	103	132	26	60	2.8	110	.590	5.0	7.50

Carburetor setting: Chokes, 36 mm.; main jet, No. 50 drill size; comp. jet, 1.70 mm. Barometer, 29.20 in. hg. February 14, 1921.

1,300	374	162.0	672	166.4	123.0	152	170	90	92	25	58	1.4	146	0.456	3.0	6.25
1,520	367	186.0	659	191.0	120.5	158	174	92	106	26	59	1.8	125	.464	3.6	6.60
1,730	339	195.5	610	200.8	111.5	154	172	102	142	27	62	2.2	117	.472	5.2	6.25
1,930	281	180.7	505	185.5	92.4	156	173	116	130	27	66	2.5	106	.564	6.0	6.50
2,020	249	167.6	448	172.1	82.0	152	170	116	138	27	.....	2.5	106	.608	6.4	.....

[1] Mixture control setting: F. R., 7.5; F. L., 0.

Carburetor setting: Chokes, 38 mm.; main jet, No. 47 drill size; comp. jet, 1.70 mm. Barometer, 29.15 in. hg. February 15, 1921.

Data for both runs: Length of brake arm: 21 inches. Kind of oil used: U. S. Spec. No. 3501, viscosity 115–125 at 210° F. Kind of fuel used: aviation gasoline W. D. Spec. 2–40; specific gravity, 0.707 at 60° F.

PROPELLER LOAD RUNS.

R. P. M.	Actual. Brake load lb.	Actual. B. H. P.	Corrected. Torque lb. ft.	Corrected. H. P.	Water. Temp. °F. In.	Water. Temp. °F. Out.	Oil. Temp. °F. In.	Oil. Temp. °F. Out.	Oil. Press. lb. per sq. in.	Carb. air temp. °F.	Man. vac. in. hg.	Fuel cons. Sec. for 3 lb.	Fuel cons. Lb. per hp. hr.	Float chamber vac. in. H_2O.	Positions[1] of alt. control.
1,740	330	191.5	588	195.0	156	172	96	122	27	63.0	2.5	113	0.499	4.4	6.9
1,620	290	156.6	517	159.5	154	170	100	112	26	64.0	3.8	146	.472	2.4	6.9
1,510	258	129.9	460	132.2	154	173	110	120	26	65.0	5.6	[2] 120	.462	1.8	6.9
1,410	225	105.8	401	107.7	156	170	118	150	26	66.0	8.0	[2] 143	.476	1.5	6.9
1,310	193	84.3	344	85.8	157	170	122	132	26	66.0	10.0	[2] 177	.483	1.4	6.9
1,190	158	62.7	282	63.8	158	171	124	120	25	66.0	11.3	[2] 218	.527	1.3	6.9

Carburetor setting: Choke, 36 mm.; main jet, No. 50 drill size; comp. jet, 1.70 mm. Barometer, 29.40 in. hg. February 14, 1921.

1,710	339	193.2	610	198.4	154	171	112	120	27	64	2.2	117	0.478	5.2	6.30
1,630	302	164.1	542	168.5	153	170	112	114	25	65	3.4	141	.466	3.4	6.30
1,520	266	134.8	478	138.5	154	170	112	108	25	.....	4.6	[2] 115	.465	2.4	6.30
1,410	233	109.5	419	112.5	156	168	108	102	25	66	6.6	[2] 139	.473	2.0	6.30
1,310	200	87.4	359	89.8	158	173	106	102	25	66	8.1	[2] 169	.488	1.8	6.30
1,200	170	68.0	306	69.8	156	170	102	92	25	66	9.5	[2] 201	.527	1.5	6.30

[1] Mixture control settings: F. R., 7.75; F. L., 0.
[2] 2 pounds fuel.

Carburetor setting: Choke, 38 mm.; main jet, No. 47 drill size; comp. jet, 1.70 mm. Barometer, 29.15 in. hg. February 15, 1921.
Data for all runs: Length of brake arm, 21 in.; kind of oil used, U. S. Spec. No. 3501, viscosity 115–125 at 210° F.; kind of fuel used, Aviation gasoline, W. D. Spec. No. 2–40; specific gravity of fuel, 0.707 at 60° F.

Carburetor test chamber—Variation of mixture ratio with altitude—Zenith carburetor, Model U. S. 52.

FULL THROTTLE.

Altitude in feet.	Standard setting.[1]		"Plain tube."[2]			Britton[3] setting, full rich.
	Full rich.	Full lean.	Setting (A).		Setting (B), full rich.	
			Full rich.	Full lean.		
	Mixture ratio, lbs. air per lb. fuel.					
0	17.90	29.44	20.56	28.00	19.07	15.36
5,000	16.46	24.75	18.94	24.51	17.90	14.69
10,000	15.20	21.15	18.02	20.81	17.08	14.02
15,000	13.52	17.69	16.45	19.84	15.33	12.97
20,000	12.20	15.86	15.52	19.81	13.84	12.23
25,000	10.39	13.94	14.42	17.88	11.91	10.39
	Fuel flow, lbs. per hour.					
0	81.8	50.7	70.6	51.8	75.4	93.7
5,000	74.6	50.6	64.7	50.0	67.1	81.8
10,000	67.9	49.2	56.4	48.9	62.1	75.5
15,000	62.6	48.3	50.9	42.0	57.3	67.7
20,000	54.9	43.2	43.2	34.0	51.9	59.5
25,000	51.1	38.6	37.2	30.1	50.3	58.2

[1] Standard setting: Choke, 36 mm.; main jet, 1.65 mm.: comp. jet, 1.70 mm.
[2] "Plain tube": Setting (A)—Choke, 36 mm.; main jet, 1.65 mm. comp. jet, 1.70 mm.; comp. fuel passage blank. Setting (B)—Choke, 38 mm.; main jet, 2.00 mm.; comp. jet, 1.70 mm.; comp. fuel passage blank.
[3] Britton setting: Choke, 36 mm.; Britton type discharge nozzle; main metering orifice No. 50 drill size; comp. jet, 1.70 mm.

Variation of mixture ratio with throttle opening (propeller load)—Zenith carburetor, Model U. S. 52, with Britton type discharge nozzle.

Nominal R. P. M. of engine.	Throttle opening, degrees.	Ground level.		20,000 feet	
		Full rich.	Blank comp. jet full rich.	Full rich.	Full lean.
		Mixture ratio, lbs. air per lb. fuel.			
1,700	64 full	19.40	22.05	14.17	17.61
1,600	39	18.51	22.45	13.67	17.60
1,500	28	18.01	23.40	13.17	16.73
1,400	22	17.30	24.49	12.53	16.93
1,300	17	16.85	27.11	12.08	17.00
		Fuel flow, lbs. per hour.			
1,700	64 full	75.8	66.1	48.5	39.9
1,600	39	69.2	57.6	45.3	35.8
1,500	28	62.1	48.0	40.9	32.1
1,400	22	55.0	38.9	35.7	26.9
1,300	17	46.6	28.8	28.2	19.8

Carburetor test chamber—Variation of mixture ratio with throttle opening (propeller load), Zenith carburetor, Model U. S. 52.

Nominal R. P. M. of engine.	Throttle opening, degrees.	Standard setting.[1]				Main jet only, ground level.		Comp. jet only,[2] ground level.	
		Ground level.		20,000 ft. altitude.					
		Full rich.	Full lean.	Full rich.	Full lean.	Full rich.	Full lean.	Full rich.	Full lean.
		Mixture ratio, lbs. air per lb. fuel.							
1,700	64 full	17.94	29.44	12.35	14.61	23.68	27.80	72.83	1,034.0
1,600	39	17.77	27.88	11.85	14.25	25.05	28.80	65.00	211.0
1,500	28	17.28	26.23	11.50	13.74	25.85	30.40	57.10	116.0
1,400	22	16.80	23.20	10.84	13.39	27.30	32.60	48.70	77.6
1,300	17	16.05	21.20	10.48	12.72	29.27	35.55	40.40	53.2
		Fuel flow, lbs. per hour.							
1,700	64 full	80.4	50.7	58.3	49.5	62.1	53.0	20.2	1.42
1,600	39	72.5	46.3	55.0	45.3	51.8	45.0	20.0	6.16
1,500	28	64.5	42.7	48.2	40.5	43.6	37.1	19.9	9.78
1,400	22	56.3	41.2	43.7	35.6	35.3	29.5	19.8	12.50
1,300	17	48.8	37.3	37.3	31.2	27.1	22.3	19.7	15.00

[1] Standard setting: Choke, 36 mm.; main jet, 1.65 mm.: compensating jet, 1.70 mm.
[2] Idle passages and compensating discharge nozzles functioning.

Zenith carburetor, Model U. S. 52, with compensating fuel passages blank ("plain tube").

Nominal R. P. M. of engine.	Throttle opening, degrees.	Ground level conditions. Setting (A). Full rich.	Setting (A). Full lean.	Setting (B), full rich.	Blank [1] comp. jet, full rich.	Blank main jet, full rich.	20,000 feet, setting (B). Full rich.	20,000 feet, setting (B). Full lean.
		Mixture ratio, lbs. air per lb. fuel.						
1,700	64 full	20.39	28.00	15.25	17.08	188.0	11.89	14.69
1,600	39	19.95	28.40	15.20	18.33	122.0	11.45	13.65
1,500	28	19.75	29.30	14.97	19.02	83.1	11.43	13.36
1,400	22	18.75	24.40	14.69	22.07	61.3	11.21	13.43
1,300	17	18.44	21.85	14.57	31.45	43.3	11.08	13.46
		Fuel flow, lbs. per hour.						
1,700	64 full	71.2	52.1	96.0	85.2	7.86	59.3	48.3
1,600	39	64.3	45.7	83.8	70.2	10.53	55.1	46.2
1,500	28	56.2	38.2	74.2	58.5	13.43	47.5	41.3
1,400	22	50.4	39.1	64.2	42.4	15.46	40.8	33.9
1,300	17	42.4	36.1	53.4	24.7	17.98	34.4	27.4

[1] Main jet, 2.00 mm.

Setting (A): Choke, 36 mm.; main jet, 1.65 mm.; compensating jet, 1.70 mm. Setting (B): Choke, 38 mm.; main jet, 2.00 mm.; compensating jet, 1.70 mm.

Carburetor test chamber—Zenith carburetor, Model U. S. 52—Standard Liberty "12" setting, full throttle.

Variation of mixture ratio with air flow, ground level, full rich. Air flow, lb. per sec.	Mixture ratio, lb. air/lb. fuel.	Variation of mixture ratio with float chamber vacuum. Altitude feet.	Float chamber vacuum in. H_2O.	Mixture ratio, lb. air/lb. fuel.	Position of control.
0.078	20.30	0	1.2	18.56	F. R.
.104	19.95	0	2.0	19.77	
.153	17.75	0	3.0	21.08	
.202	17.00	0	4.0	23.78	
.254	17.04	0	5.3	32.87	F. L.
.307	17.85	5000	0.8	17.77	F. R.
.359	18.30	5000	2.0	19.36	
.407	19.14	5000	3.0	21.98	
.458	19.25	5000	4.0	24.92	F. L.
.520	19.50	10000	0.6	17.11	F. R.
		10000	2.0	18.58	
		10000	3.3	22.50	F. L.
		15000	0.5	15.25	F. R.
		15000	1.5	17.01	
		15000	2.5	19.04	F. L.
		20000	0.3	13.18	F. R.
		20000	1.0	14.41	
		20000	1.8	16.60	F. L.
		25000	0.4	11.35	F. R.
		25000	1.0	12.87	
		25000	1.5	13.83	F. L.

Carburetor test chamber—Air flow through one carburetor, Liberty "12."—Full throttle.

Altitude, 1,000's feet.	Depression at carb. intake in Hg.	Density, per cent.	Wt. air, constant engine speed, lb. per sec.	Per cent of ground speed.	Wt. air, reduced speed,[1] lb. per sec.
0	0.2	100.00	0.405	100.0	0.405
5	4.1	86.29	.349	98.5	.344
10	7.8	73.70	.298	95.9	.286
15	11.2	62.37	.252	93.4	.235
20	14.2	52.37	.212	88.8	.188
25	16.8	43.68	.177	83.4	.148

[1] "Reduced speed" refers to the decrease in R. P. M. of the engine propeller unit at altitudes.

NOTE.—Measured weight of air at 1,700 R. P. M., full throttle ground level: Engineering Division test, 0.370 lb./sec.; Bureau of Standards test, 0.450 lb./sec.

Propeller load runs.

Nominal R. P. M.	Throttle opening, deg.	Air flow, per cent.	Air flow, lb./sec.
	Ground level.		
1,700	64	100.0	0.405
1,600	39	88.6	.350
1,500	28	77.0	.312
1,400	22	65.5	.265
1,300	17	54.0	.219
	20,000 feet altitude.		
1,700	64	100.0	0.188
1,600	39	88.6	.167
1,500	28	77.0	.145
1,400	22	65.5	.123
1,300	17	54.0	.103

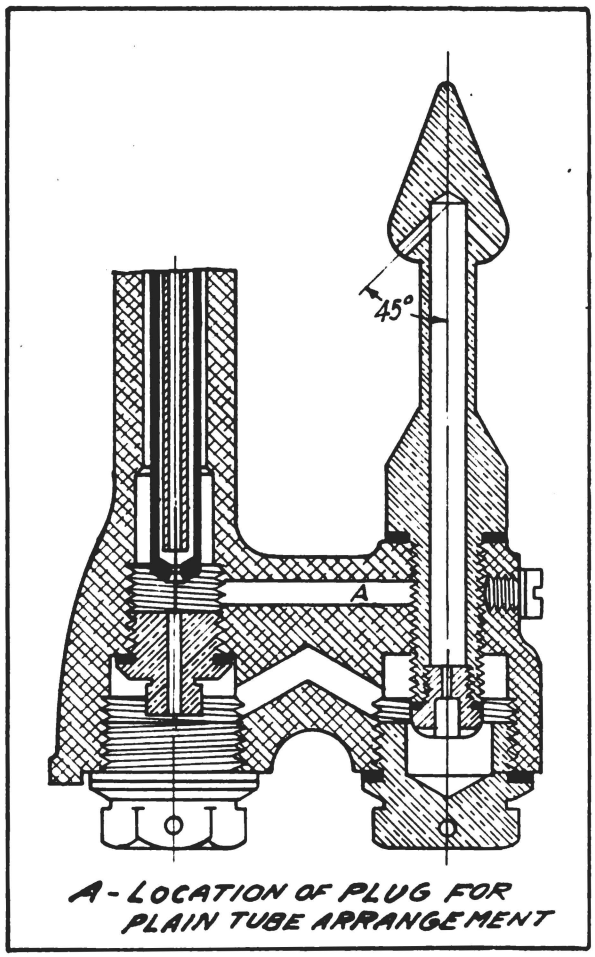

FIG. 15.—Britton type discharge nozzle and metering orifice as fitted to Zenith carburetor, Model U. S. 52.

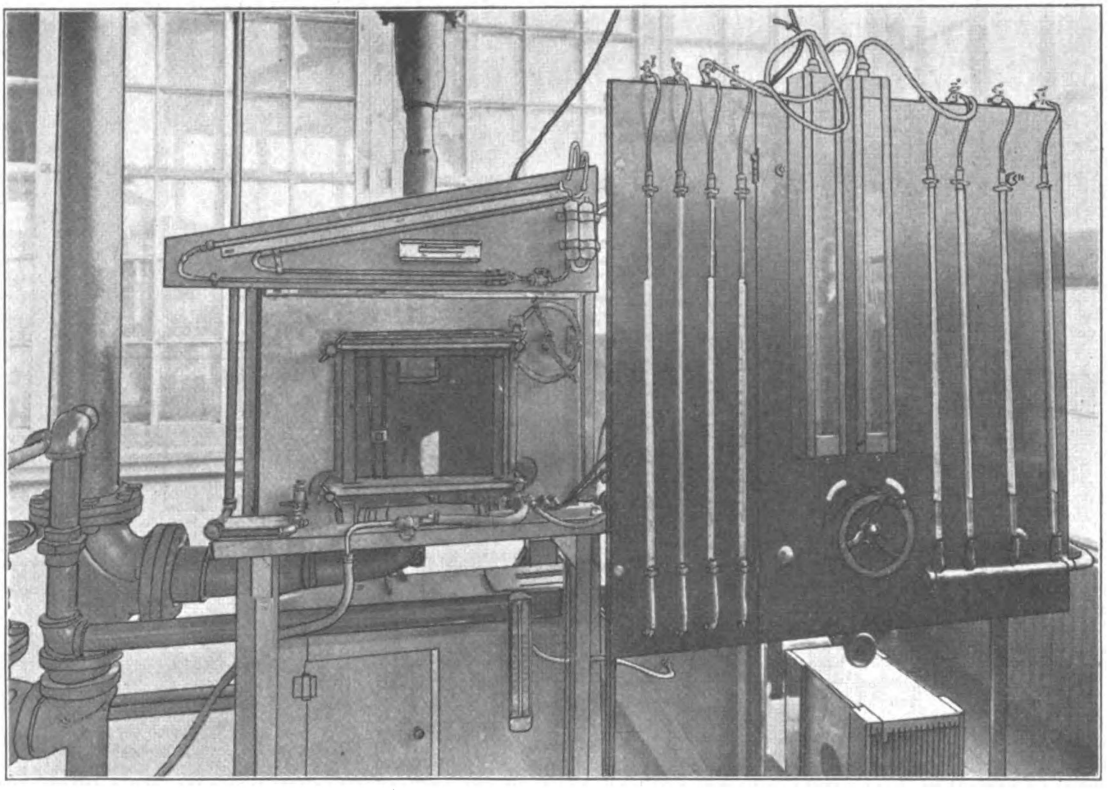

FIG. 16.—Carburetor test chamber and manometer board.

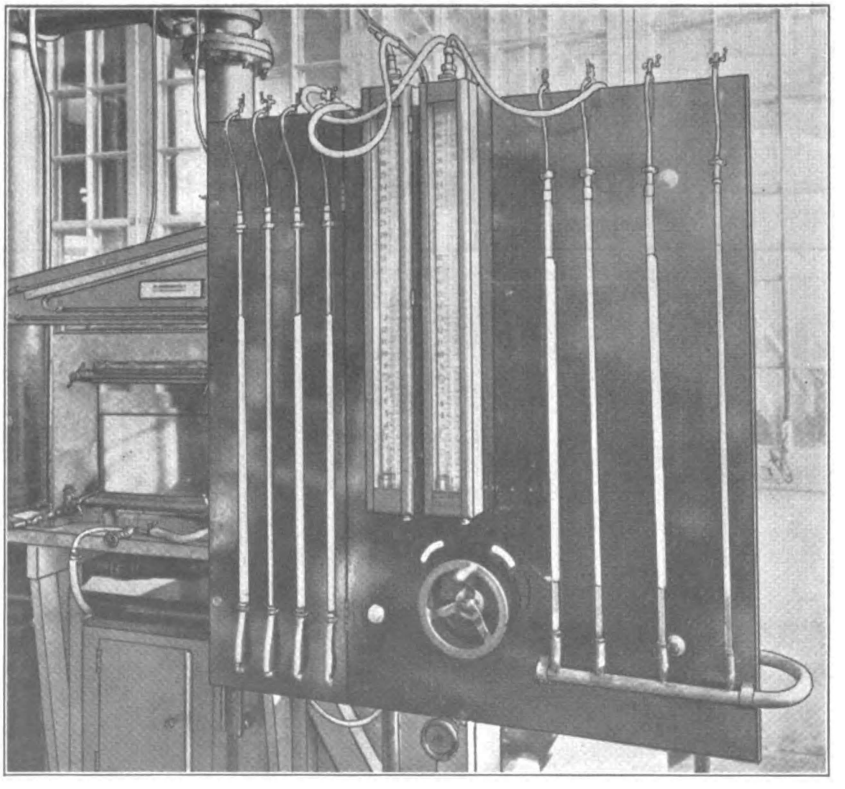

FIG. 17.—Carburetor test chamber and manometer board.

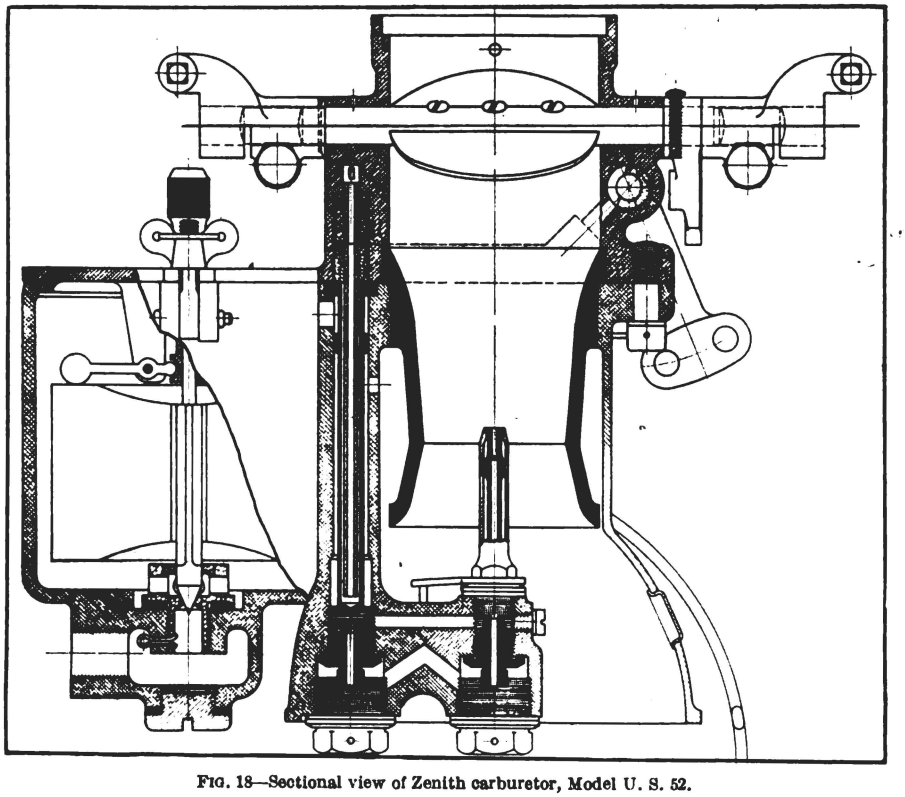

FIG. 18—Sectional view of Zenith carburetor, Model U. S. 52.